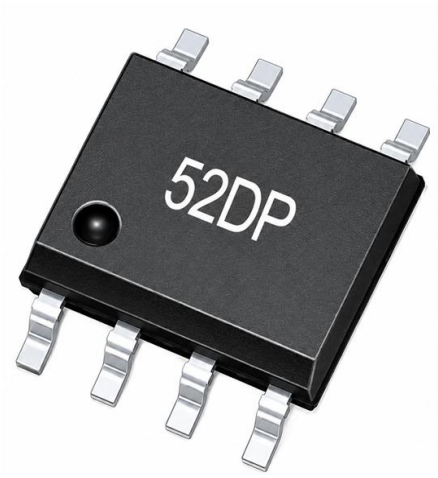


Figure 1. Physical Photos of AT9452

FEATURES

- Input Voltage Range: 5V to 40V
- 500mΩ Internal Power MOSFET
- 1.8MHz Fixed Switching Frequency
- Internally Compensated
- Stable with Ceramic Output Capacitors
- Internal Soft-start
- Precision Current Limit without Current Sensing Resistor
- High Efficiency: >90%
- 230μA Operating Quiescent Current
- Low Shutdown Mode Current: <2μA
- ESOP8 Package

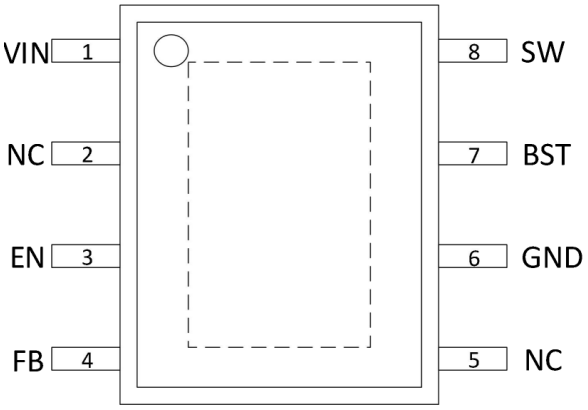
APPLICATIONS

- High Voltage Power Conversion
- Automotive Systems
- Industrial Power System
- Distributed Power System
- Battery Powered System

DESCRIPTION

The AT9452 is a monolithic, step-down, switch-mode converter with a built-in power MOSFET. It achieves a 1.0A peak-output current over a wide input voltage range. Current mode operation provides a fast transient response and eases loop stabilization. The wide input voltage range (5V to 40V) provides high efficiency output of 1.0A current. Low shutdown mode quiescent current of 2mA (or less) is suitable for battery-powered applications. High efficiency at light load condition is achieved by scaling down the switching frequency to reduce the switching and gate driving losses. The frequency folding technique helps prevent the inductance current from running out of control at startup. Hot shutdown provides reliable, fault tolerant operation.

PIN CONFIGURATIONS



ESOP8

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PIN DESCRIPTION

Table 1: Pin Function

Pin #	Symbol	Description
1	VIN	Input Power Supply. All internal control circuits are powered, including switching tubes. A decoupling capacitor to ground is required close to this pin to reduce switching spikes.
2	NC	No connected.
3	EN	Enable input. Pull this pin below the specified threshold to disable. Pull it above the specified threshold to enable. Connect 100kΩ resistor to IN, it can be turned on automatically.
4	FB	Feedback. This is the input to the error amplifier. An external resistive divider connected between the output and GND is compared to the internal +0.8V reference to set the regulation voltage.
5	NC	No connected.
6	GND	Ground. It should be connected as close as possible to the output capacitor, avoid high current switching paths.
7	BST	Bootstrap. This is the positive power supply for the internal floating high side MOSFET driver. Connect a bypass capacitor between this pin and SW pin.
8	SW	Switch node. This is the output from the high-side switch. Allow VF Schottky diode to ground is required close to this pin to reduce switching spikes.

Table 2. Absolute Maximum Ratings

Parameter		Rating
Supply Voltage (V_{IN})		−0.3V ~ 43V
Maximum Output Voltage (V_{OUT})		0.95×V_{IN}
Switch Voltage (V_{SW})		−0.3V ~ V_{IN}(MAX)+0.3V
BST to SW		−0.3V ~ 6.0V
All Other Pins		−0.3V ~ 6.0V
Maximum Output Current		1A
Junction Temperature		150°C
Lead Temperature		260°C
Thermal resistance	θ_{JA}	Thermal resistance
	θ_{JC}	
Operating Ambient Temperature		–40°C ~ +85°C
Storage Temperature		–65°C ~ +150°C
Operating Junction Temperature (T_J)		–40°C ~ +125°C

Note: The maximum limit means that the chip may be permanently damaged if it exceeds the working range. Electrical parameters define the specifications for the DC and AC parameters of the device within its operating range and under test conditions that ensure specific performance indicators.

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ELECTRICAL CHARACTERISTICS

(At T_A = +25°C, V_{IN} = 12V, unless otherwise noted.)

Table 3.

Parameter	Symbol	Test Conditions	Min.	Typ.	Max.	Unit
Feedback Voltage	V_{FB}		0.778	0.794	0.810	V
Upper Switch ON Resistance	R_{SW}	$V_{BST} - V_{SW}$ = 5V		500		mΩ
Upper Switch Leakage	I_{swleak}	V_{EN}=0V, V_{SW}=0V		0.1	1	μA
Transconductance	G_{CS}	COMP to SENSE		3		A/V
Minimum Operating Voltage	V_{IN_MIN}		4.2			V
UVLO Up Threshold	V_{IN}(UVLO)		3.3		4.2	V
UVLO Hysteresis	V_{IN}(UVLO)hys			0.8		V
Soft-Start Time	t_{ss}	FB from 0 to1.8V		0.5		ms
Oscillator Frequency	f_{osc}		1.4	1.8	2.2	MHz
Minimum Switch ON Time	T_{ON_MIN}			100		ns
Shutdown Current	I_{SD}	V_{EN}<0.3V		1.5	2	μA
Quiescent Current	I_Q	V_{fb}=0.9V, No load			250	μA
Thermal Shutdown				200		°C
Enable Up Threshold	V_{ENH}		1.7			V
Enable Threshold Hysteresis	V_{EN_hys}			0.6		V
Enable Clamp Voltage				7.5		V

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BLOCK DIAGRAM

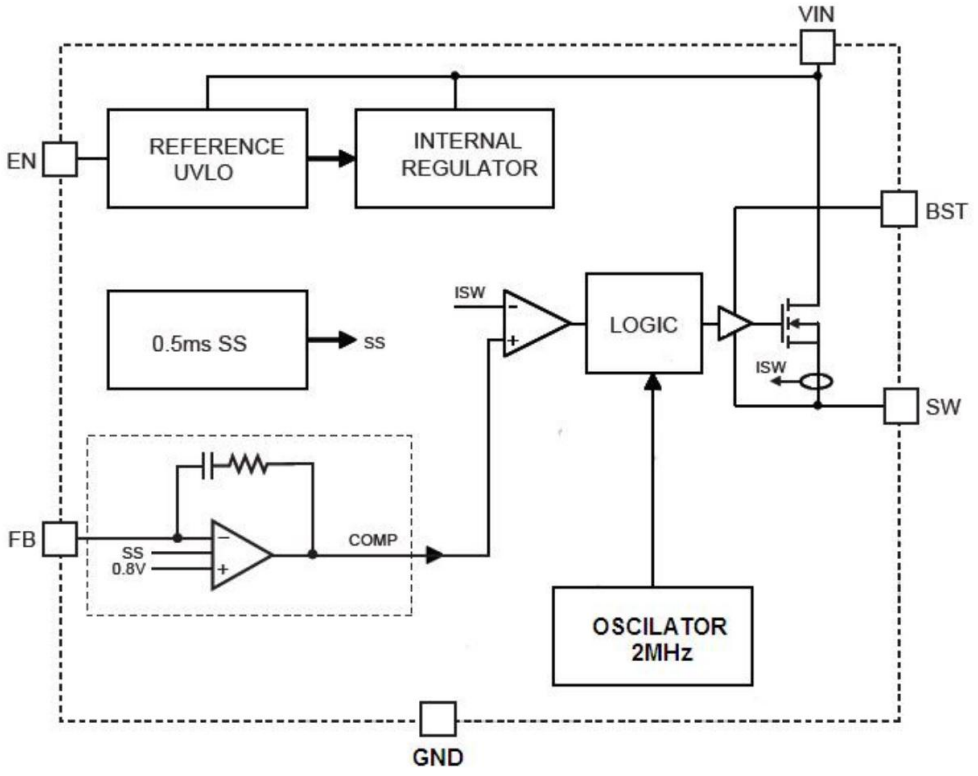


Figure 2. Block Diagram

TYPICAL APPLICATION

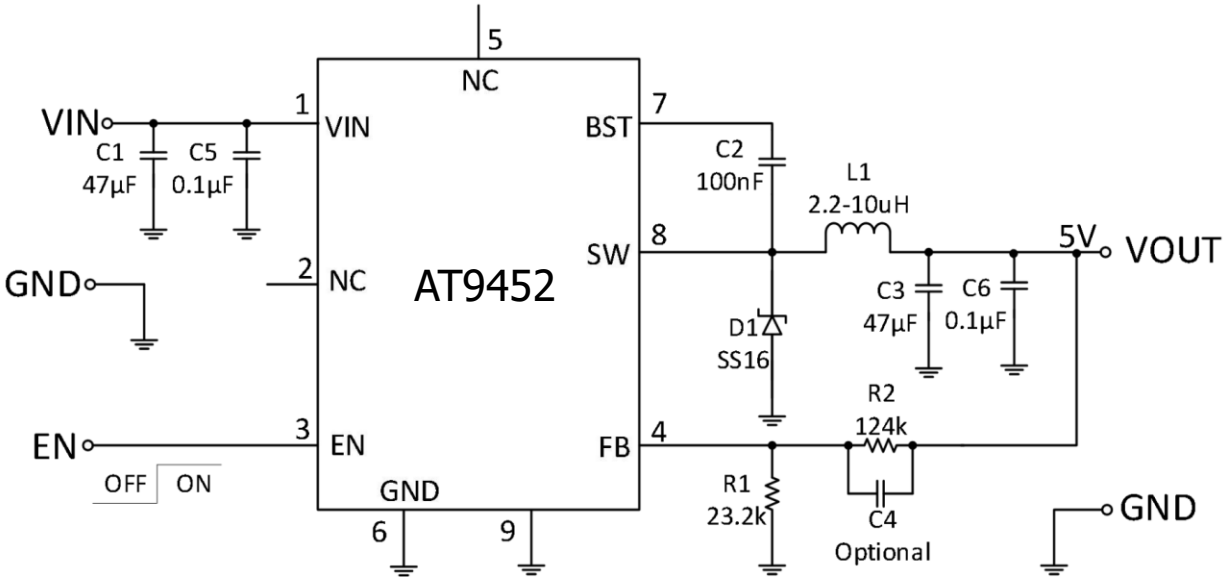


Figure 3. 5V Output Typical Application

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DETAILED DESCRIPTION

The AT9452 is a 1.8MHz, non-synchronous, step-down(buck) regulator with integrated internal high side MOSFET. It provides internally compensated single 1.0A high efficient output. It features wide input voltage range, internal soft-start control, and precision current limit. Low operational quiescent current feature is suit for battery powered applications.

PWM Control

At heavy load or moderate load condition, the AT9452 operates in a fixed frequency, peak current control mode to regulate the output voltage. A PWM cycle is initiated by the internal clock. The power MOSFET is turned on and remains on until its current reaches the value set by COMP voltage. When the power switch is off, it remains off for at least 100ns before the next cycle starts.

If in one PWM period, the current in the power MOSFET does not reach COMP set current value, the power MOSFET remains on, saving a turn-off operation.

Pulse Skipping Mode

Under light load, the circuit enters pulse jump mode to improve light load efficiency. The determination of pulse jump is based on its internal COMP voltage. If the COMP terminal is below the internal sleep threshold, a pause command is generated to prevent the clock pulse from being turned on, so the power MOSFET cannot be turned on as instructed, saving drive and switching losses. The pause command will also put the entire chip into sleep mode, consuming very low static current to further improve light load efficiency.

When the COMP voltage is above the sleep threshold, the pause signal is reset and the chipre turns to normal PWM operation. Each time the pause instruction changes state from low to high, an on signal is immediately generated to turn on the power MOSFET.

Error Amplifier

The error amplifier consists of an internal operational amplifier with a resistance-capacitance feedback network connected between its output (internal COMP node) and negative input (FB). When FB is below its internal reference voltage (REF), the COMP output is driven higher by the op amp, resulting in a higher switching peak current output, and therefore more energy is transferred to the output, and vice versa.

Typically, FB is connected to a voltage divider consisting of RUP and RDN, where the RDN is connected to FB and ground, while RUP is connected to the voltage output node and FB. RUP controls the gain of the error amplifier in conjunction with the internal compensation RC network.

Internal Regulator

Most of the internal circuitry is powered on by the 2.6V internal regulator. When VIN is higher than 4.6V, the output of the regulator is in full regulation. When VIN is lower, the output degrades.

Enable-Control

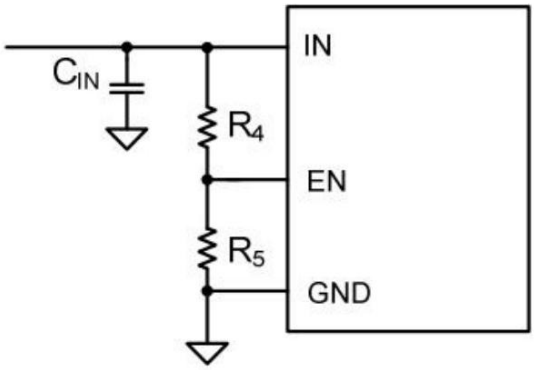
The circuit has a specialized enable control terminal EN. When the VIN is high enough, the chip can be enabled and disabled via the EN side. The high level is valid. Lower limit 1.7V. Threshold Hysteresis is 0.6 V. When suspended, the EN terminal is pulled internally to the ground and the chip is disabled. When EN reaches 0V, the chip enters the lowest shutdown current mode. When EN is above zero but below its threshold, the chip remains in shutdown mode but the shutdown current increases slightly. Pulling the EN pin voltage below the specified threshold will shut down the chip. In off mode, the AT9452 shutdown current drops to less than 2μA.

Pulling the EN pin high will open the chip. Connect the 100K resistor to the Vin pin to automatically start the chip, or you can control the starting voltage through the resistance voltage division.

$V_{IN}*R_5/(R_4+R_5) > V_{ENR}$

V_{ENR} is the ascending threshold voltage of EN, the lower limit of which is 1.7V.

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Under Voltage Lockout (UVLO)

VIN Under voltage lockout (UVLO) is implemented to protect the chip from operating at insufficient supply voltage.

Internal Soft Start

Soft start is used to prevent the output voltage of the converter from overshooting when starting. When the chip is started, the internal circuit generates a soft start voltage (SS) starting from 0V, set by the soft start time, and rising slowly. When it is below the internal reference REF, SS predominates and the error amplifier uses SS instead of REF as a reference. When SS is higher than REF, REF is dominant. SS is also associated with FB. SS can be much lower than FB, but only slightly higher. SS will also track FB falls if FB falls unexpectedly, this feature is designed to deal with short circuit recovery. When the short circuit is eliminated, the SS ramp rises as a soft start process that restarts, preventing output voltage overshoot.

Thermal Shutdown

Thermal shutdown is implemented to prevent the chip from thermally running away. When the temperature is higher than its upper threshold, the AT9452 will shut down. When the temperature is lower than its lower threshold, the chip is enabled again.

Suspension Drive and Bootstrap Charging

The floating power MOSFET driver is powered by an external bootstrap capacitor. The levitating drive has its own UVLO protection. The opening threshold of the UVLO is about 2.9V and backlash is about 300mV. During UVLO, the SS voltage is reset to zero. When the UVLO is removed, the controller begins the soft start process.

The bootstrap capacitor is charged by an internal bootstrap regulator and held at about 5V. When the voltage between BST and SW falls below the regulated value, a PMOS switch tube connecting VIN to BST is opened, and the charging current goes from VIN, BST and then to SW. The external circuit should provide a sufficient voltage margin to facilitate charging.

As long as the VIN is high enough above the SW, the bootstrap capacitor can be charged. When a power MOSFET is on, VIN is approximately equal to SW, so the bootstrapped capacitor cannot be charged. When the external continuation diode is turned on, the difference between VIN and SW is the largest, which is the best time for charging. When there is no current in the inductor, SW is equal to the output voltage VOUT, and the voltage between VIN and VOUT can be used to charge the bootstrap capacitor. At a high duty cycle, the charging time of the bootstrap capacitor decreases, and the bootstrap capacitor may not be effectively charged.

When the external circuit does not have sufficient voltage and time to charge the bootstrap capacitor, an additional external circuit can be used to ensure the bootstrap voltage within the normal operating range.

The UVLO of the hover drive is not transmitted to the controller.

The dc static current of the suspension driver is about 20μA. Make sure the supply current on the SW side is higher than this.

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Current Comparator and Current Limit

Power MOSFET current is sampled accurately through a current sampling MOSFET. It is then sent to a high-speed current comparator for current-mode control. The sampling current serves as one of the inputs to the current comparator. When the power MOSFET is on, the comparator first fades and then turns on to avoid noise. The comparator then compares the power switch current with the COMP voltage, and when the sampling current is higher than the COMP voltage, the comparator output is low and the power MOSFET is turned off. Internal power the maximum current of the MOSFET is limited by internal cycles.

Startup and Shutdown

When VIN and EN are both above their respective thresholds, the chip starts working. The reference power supply section starts first, producing a steady reference voltage and current. An internal voltage regulator is then activated, which provides a stable voltage to the rest of the circuit. When the internal voltage reaches the upper rail, an internal timer keeps the power MOSFET 50μs off to prevent startup fluctuations. The internal soft start section kicks in, which keeps the SS output low to make sure the rest of the circuit is ready, then slowly ramps up.

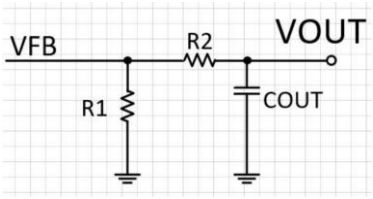
Three conditions will turn off the chip: EN low, VIN low, and thermal shutdown. In the shutdown sequence, the signal path is blocked first to avoid any failure triggers. Then COMP voltage and internal power supply voltage drop. The floating drive is not subject to the shutdown command, but its charging path is disabled.

APPLICATION CIRCUITS

Setting the Output Voltage

The output voltage is set using a resistive voltage divider from the output voltage to FB pin.

$V_{FB}=V_{OUT}*R1/(R1+R2)$



Inductor

The inductor is required to supply constant current to the output load. A larger value inductor will result in lower output ripple voltage. Generally, a good rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be approximately 30% of the maximum load current. Also, make sure that the peak inductor current is below the maximum switch current limit, it will not saturate at the maximum inductance peak.

$$L = \frac{V_{out} \times (V_{in} - V_{out})}{V_{in} \times \Delta I_L \times f_{OSC}}$$

Where ΔI_L is inductance ripple current. If the maximum load current is 2A, the inductor ripple current is selected to be about 30%. The maximum peak inductance current is:

$$I_{L(MAX)} = I_{LOAD} + \frac{\Delta I_L}{2}$$

Under light load conditions up to 100mA, larger inductors are recommended to improve efficiency.

Input Capacitor

The input capacitor can be electrolytic, tantalum or ceramic. When using electrolytic or tantalum capacitors, a small, high quality ceramic capacitor, i.e. 0.1μF, should be placed as close to the IC as possible. When using ceramic capacitors, make sure they have sufficient capacitance values to prevent input from excessive voltage ripple.

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Output Capacitor

The output capacitor (Cout) is used to maintain the DC output voltage. Low ESR electrolytic capacitors are recommended to keep the output voltage ripple low. The characteristics of the output capacitor will affect the stability of the voltage stabilizer system.

Catch Diode

When the power MOSFET is off, the output diode is inductance current freewheeling. Use Schottky diodes to reduce the loss caused by the diode's forward guide on voltage and reverse recovery. The average current flowing through the diode can be estimated by the following formula:

$$I_D = I_{OUT} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

The selected diode must have a reverse voltage rating equal to or greater than V_{INMAX}. The peak current rating of the diode must be greater than the maximum inductor current.

PCB layout guidelines:

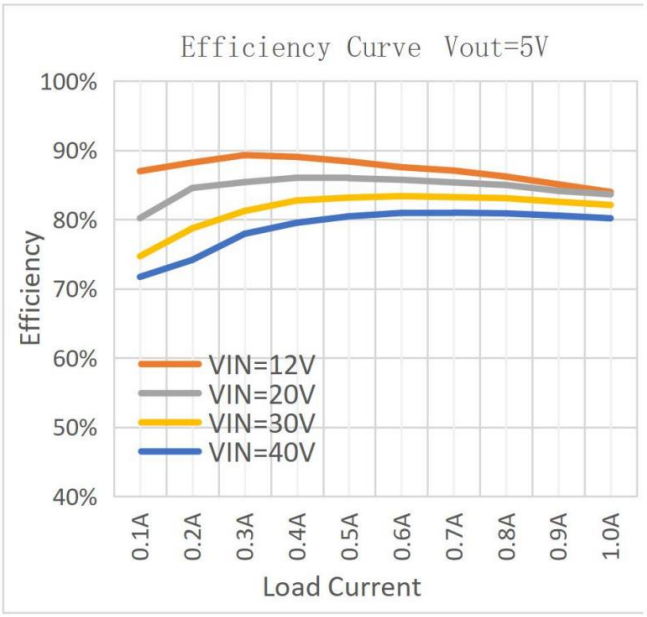
PCB layout is very important for the circuit to achieve stable operation. The following suggestions are for your reference:

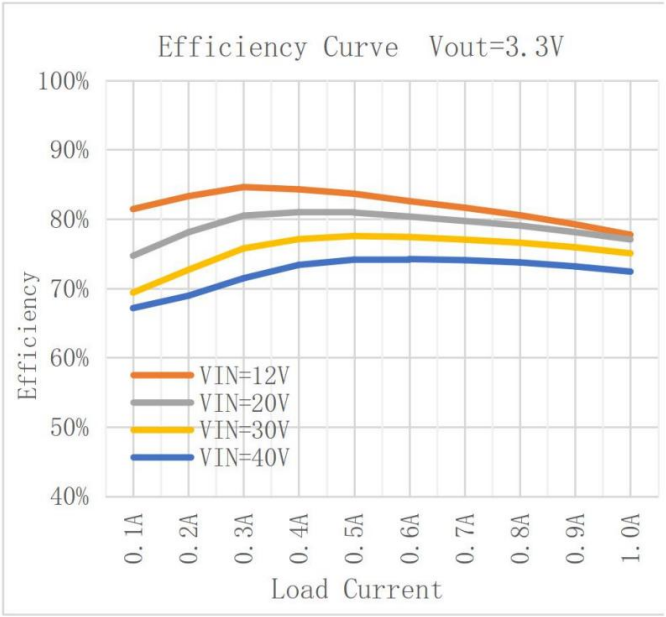
1. Switching current path as short as possible, input capacitance, high-side MOSFET and external high-speed switching Schottky diode formed loop area as small as possible.
2. Bypass ceramic capacitor is placed near the VIN pin.
3. All feedback circuit connections should be short and direct, with feedback resistance and compensation elements as close to the chip as possible.
4. SW route should be far away from sensitive simulated areas, such as FB.
5. SW, IN, and especially ground should be connected to a large copper-clad area to cool the chip, improve thermal performance, and enhance long-term reliability.

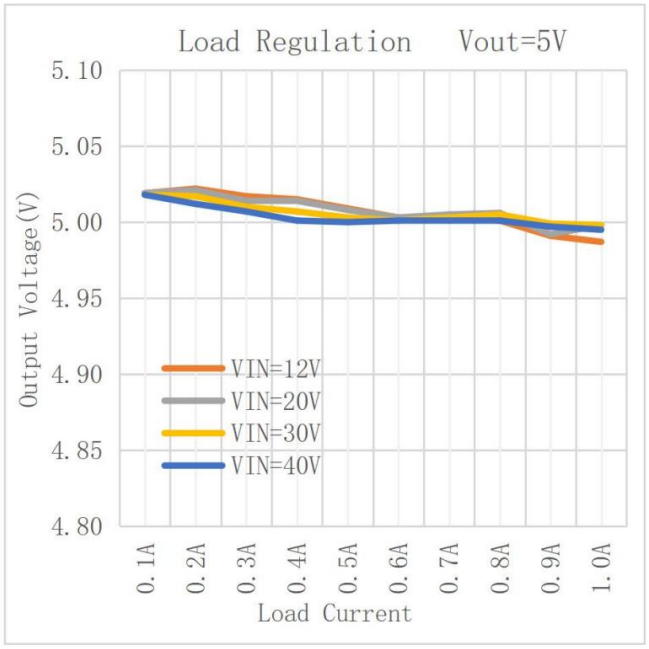
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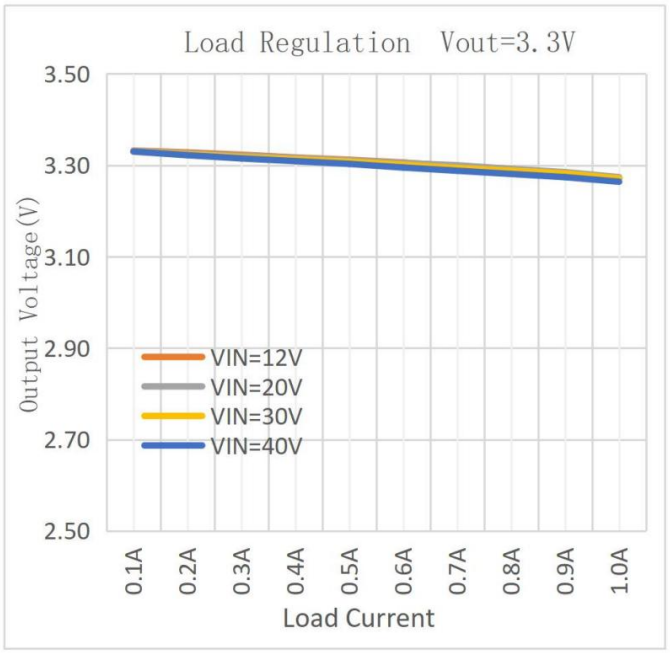
TYPICAL CHARACTERISTICS

At T_A = +25°C, VIN = 12V, C_{IN}=47µF, C_{OUT}=100µF, L = 4.7Mh, unless otherwise noted.

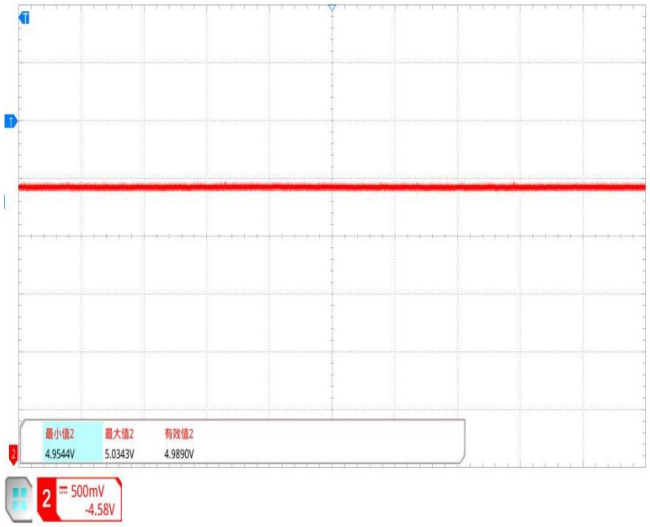




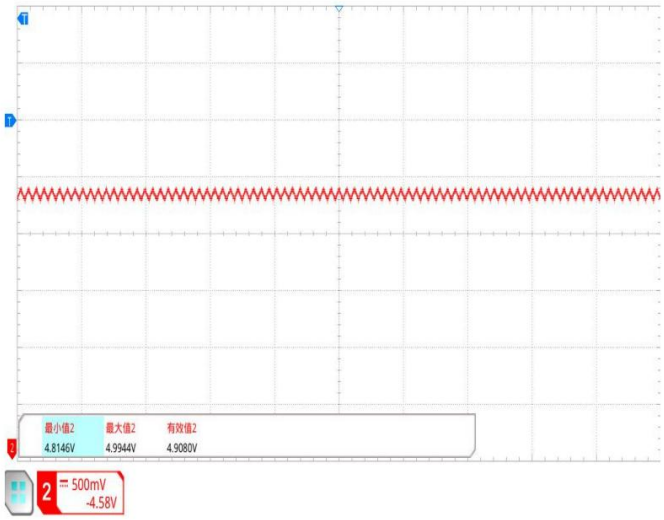




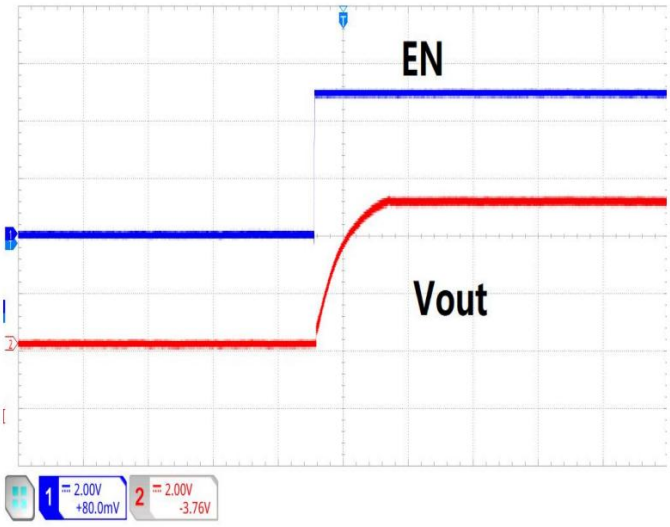
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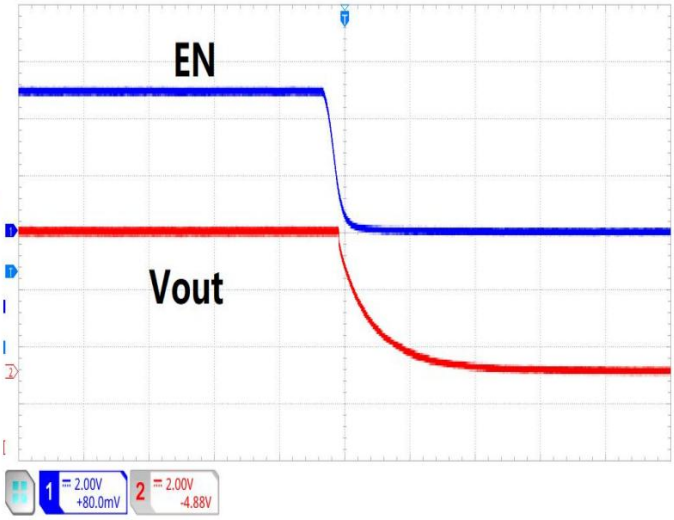
Vin=12V,Vout=5V,Io=NO Load



Vin=12V,Vout=5V,Io=1A



Vin=12V,Vout=5V,Io=1A Time (1ms/div)

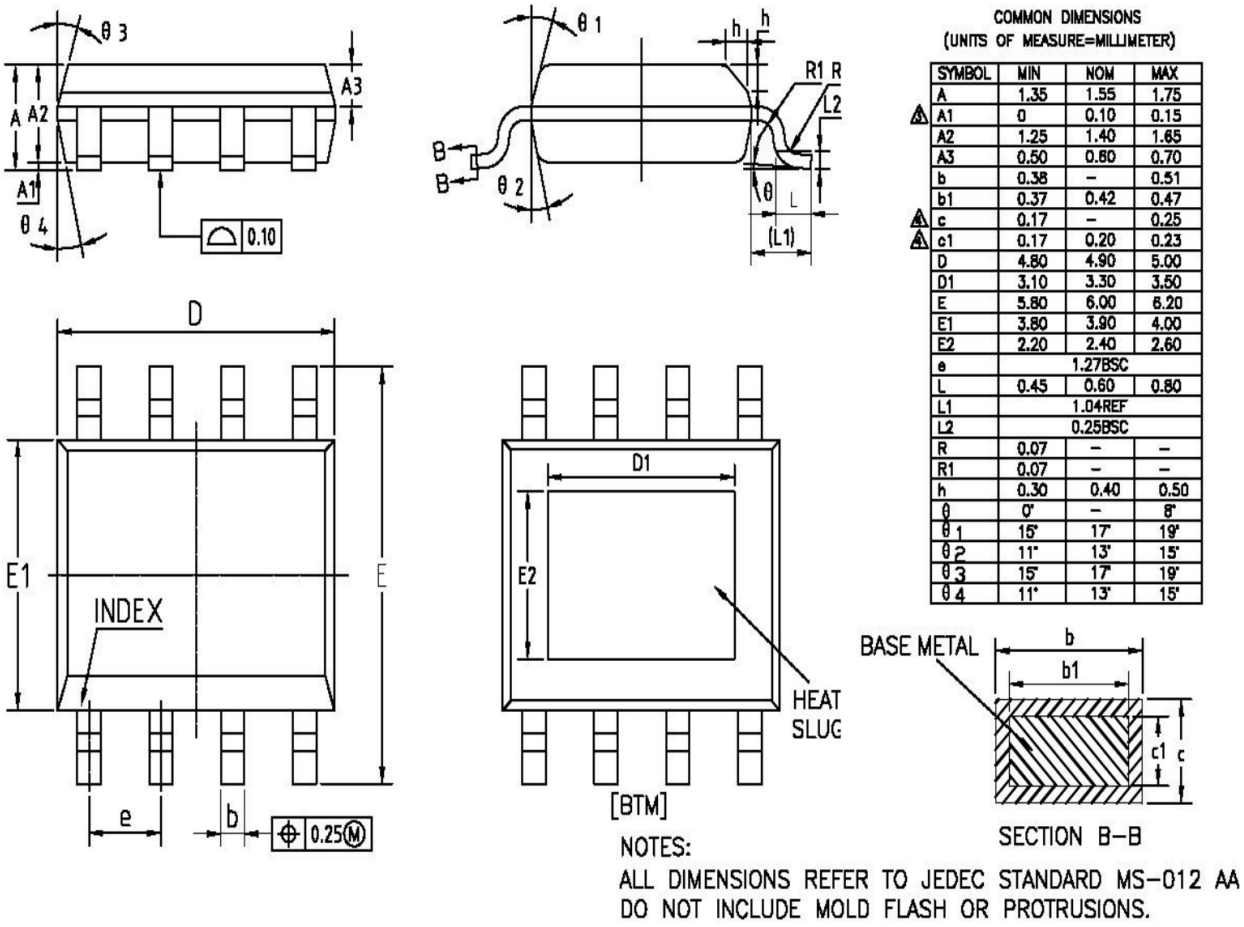


Vin=12V,Vout=5V,Io=1A Time (1ms/div)

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OUTLINE DIMENSIONS

ESOP8



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	1.35	1.55	1.75
A1	0	0.10	0.15
A2	1.25	1.40	1.65
A3	0.50	0.60	0.70
b	0.38	–	0.51
b1	0.37	0.42	0.47
c	0.17	–	0.25
c1	0.17	0.20	0.23
D	4.80	4.90	5.00
D1	3.10	3.30	3.50
E	5.80	6.00	6.20
E1	3.80	3.90	4.00
E2	2.20	2.40	2.60
e		1.27BSC	
L	0.45	0.60	0.80
L1		1.04REF	
L2		0.25BSC	
R	0.07	–	–
R1	0.07	–	–
h	0.30	0.40	0.50
θ	0°	–	8°
θ1	15°	17°	19°
θ2	11°	13°	15°
θ3	15°	17°	19°
θ4	11°	13°	15°

NOTES:
ALL DIMENSIONS REFER TO JEDEC STANDARD MS-012 AA
DO NOT INCLUDE MOLD FLASH OR PROTRUSIONS.

Symbol	Dimensions In Millimeters			Dimensions In Inches			Symbol	Dimensions In Millimeters			Dimensions In Inches		
	Min.	Typ.	Max.	Min.	Typ.	Max.		Min.	Typ.	Max.	Min.	Typ.	Max.
A	-	-	1.77	-	-	0.070	D	4.7	4.9	5.1	0.185	0.193	0.201
A1	0.08	0.18	0.28	0.003	0.007	0.011	E	5.8	6	6.2	0.223	0.236	0.244
A2	1.2	1.4	1.6	0.047	0.055	0.063	E1	3.7	3.9	4.1	0.146	0.154	0.161
A3	0.55	0.65	0.75	0.022	0.026	0.030	e	1.27(BSC)			0.05(BSC)		
b	0.39	-	0.48	0.015	-	0.019	L	0.5	0.65	0.8	0.020	0.0260.031	
b1	0.38	0.41	0.43	0.015	0.016	0.017	L1	1.05(BSC)			0.041(BSC)		
c	0.21	-	0.26	0.008	-	0.010	θ	0°	-	8°	0°	-	8°
D1	3.1	3.3	3.5	0.122	0.130	0.138	E2	2.2	2.4	2.6	0.087	0.094	0.102

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ORDERING INFORMATION

Part Number	Buy Now
AT9452	

NOTICE

1. It is important to carefully read and follow the warnings, cautions, and product-specific notes provided with electronic components. These instructions are designed to ensure the safe and proper use of the component and to prevent damage to the component or surrounding equipment. Failure to follow these instructions could result in malfunction or failure of the component, damage to surrounding equipment, or even injury or harm to individuals. Always take the necessary precautions and seek professional assistance if unsure about proper use or handling of electronic components.
2. Please note that the products and specifications described in this publication are subject to change without prior notice as we continuously improve our products. Therefore, we recommend checking the product descriptions and specifications before placing an order to ensure that they are still applicable. We also reserve the right to discontinue the production and delivery of certain products, which means that not all products named in this publication may always be available.
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10. Despite operating the electronic modules as specified, malfunctions or failures may occur before the end of their usual service life due to the current state of technology. Therefore, it is crucial for customer applications that require a high level of operational safety, especially in accident prevention or life-saving systems where the malfunction or failure of electronic modules could pose a risk to human life or health, to ensure that suitable measures are taken. The customer should design their application or implement protective circuitry or redundancy to prevent injury or damage to third parties in the event of an electronic module malfunction or failure.

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